



Future Fuels

**Flag Officers
&
Senior Executive Service**

**4 October 2005
The Pentagon Auditorium**

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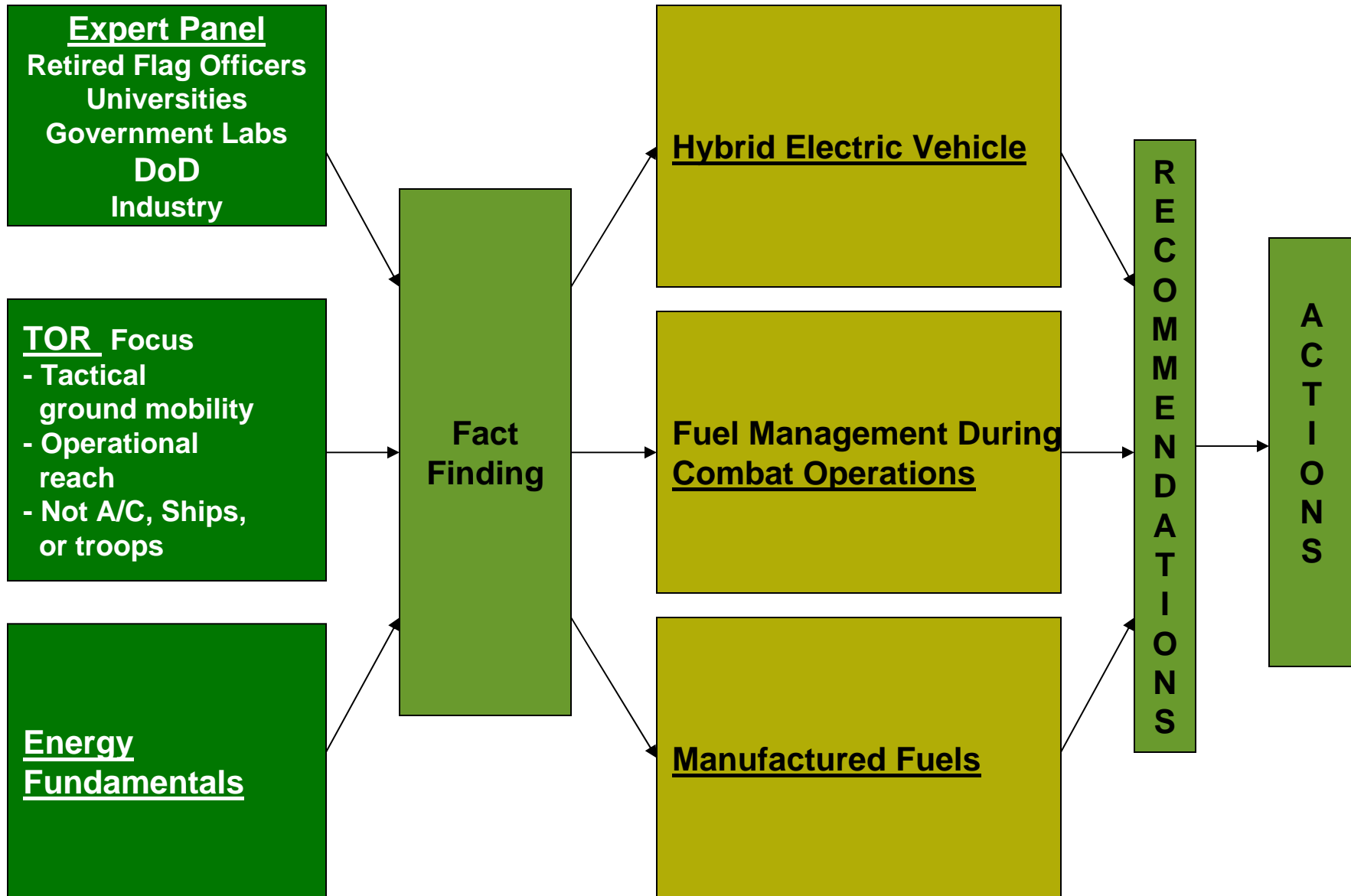
- *Focus on tactical ground mobility and increasing operational reach*
- *Identify, review, and assess*
 - *Technologies for reducing fuel consumption, including alternative propulsion technologies*
 - *Militarily useful alternative fuels*
- *Recommend a strategy to leverage the cooperative research among DoD, DoE, and industry*

“Unleash us from the tether of fuel.”

-LtGen James Mattis, USMC



Study Flow





Fact-Finding Briefings from...

Service Perspectives

MCCDC, HQMC
DASN (RDT&E), ONR, NRL
HQDA (S&T), TARDEC, Army PM (Unit of Action)
USAF AFRL

Energy & Emissions Policy

DoE, OSD, OPNAV N42

Fuel Logistics

MCCDC, Army TRADOC, DLA/DESC

Propulsion & Energy Storage Systems

Oshkosh, Caterpillar, General Dynamics LS
U Wisconsin, Battelle, DoE NTRC, NRC
ONR, TARDEC, ARL, NAVSEA, NAVAIR
Japan: Toyota
UK: Rolls-Royce, DSTL, Royal Navy

Alternative Fuels & Fuel Manufacturing

DoE HQ, Oak Ridge National Laboratory
OSD, DARPA, ONR, NRL, NSWC
Shell Oil, Baard Generation, Rentech

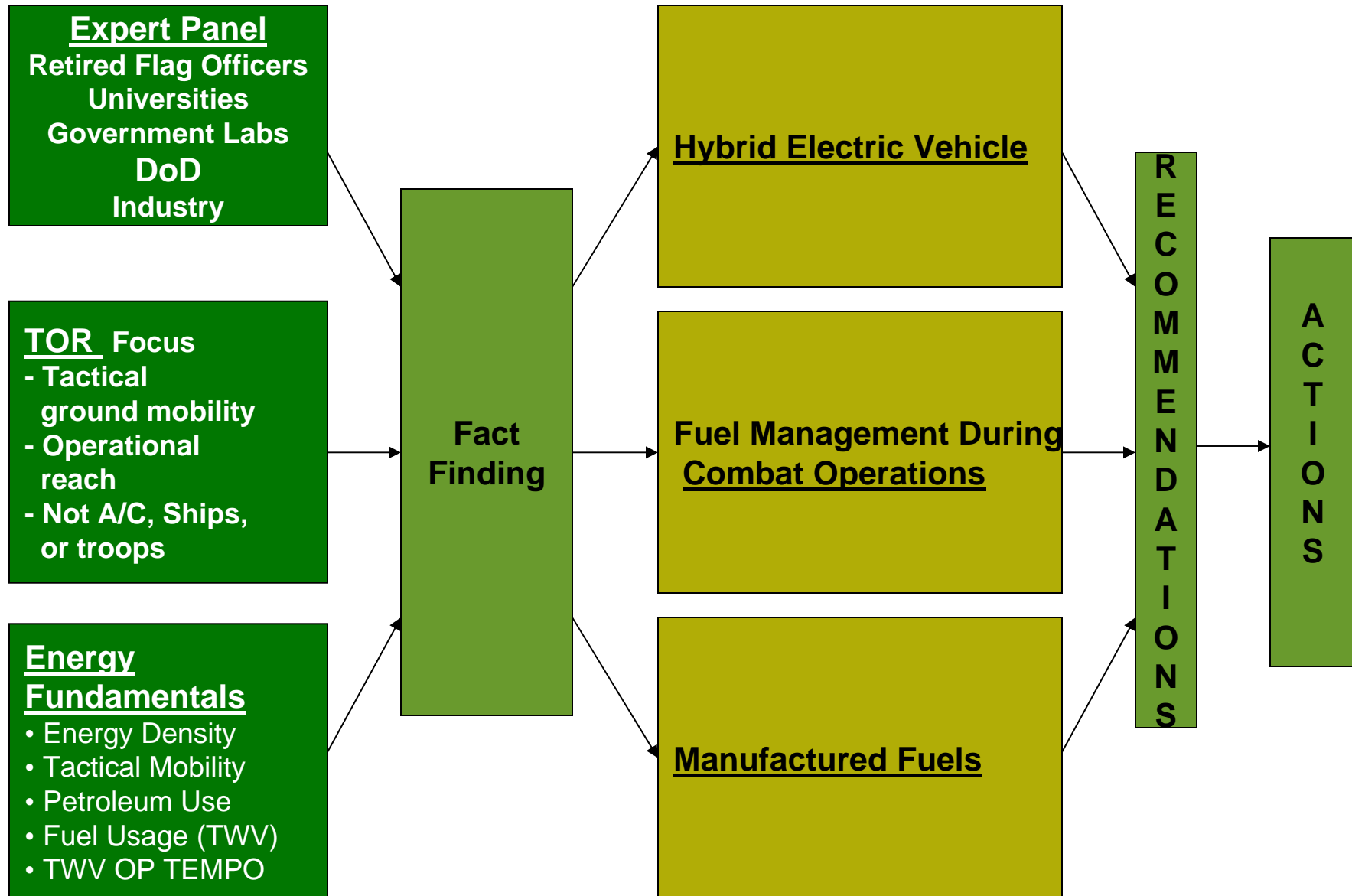


Takeaways

- ***Fuel Economy is Combat Power ...
a key performance parameter***
- ***Liquid hydrocarbons ...
the ideal transportation fuel***
- ***No single “silver bullet” to 50% reduction in fuel
consumption***
- ***Key actions:***
 - ***Commit to hybrid electric architecture for Tactical
Wheeled Vehicles (TWV)***
 - ***Long term commitment to manufactured liquid
hydrocarbon fuels from domestically abundant
feedstocks***

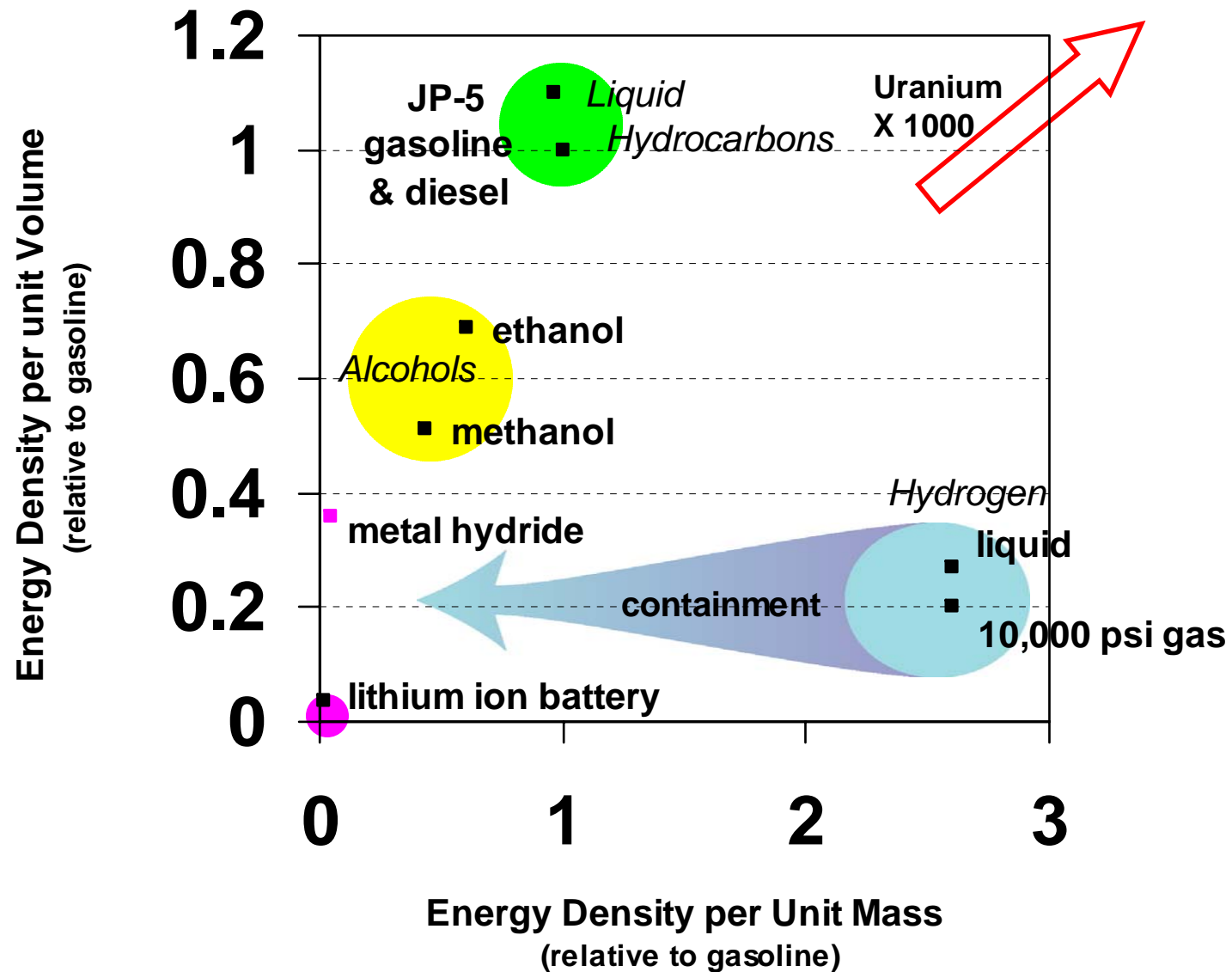


Study Flow





Energy Density of Fuels





Tactical Mobility Fuel

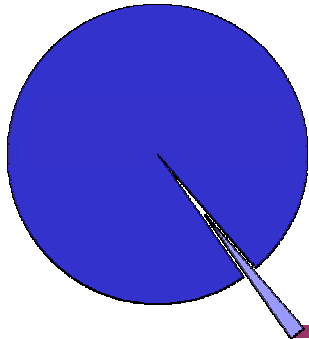
- ***Tactical Vehicle designs impose severe limitations on volume and weight***
- ***Energy Density is therefore the primary figure of merit for transportation fuels***
- ***Hydrogen presently unsuitable for a tactical mobility fuel***
 - ***made using other fuels***
 - ***containment reduces energy density a factor of 10 to 20***

Liquid Hydrocarbons are the ideal fuel for tactical mobility

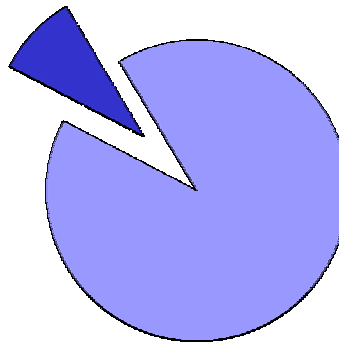


Petroleum Usage 2003

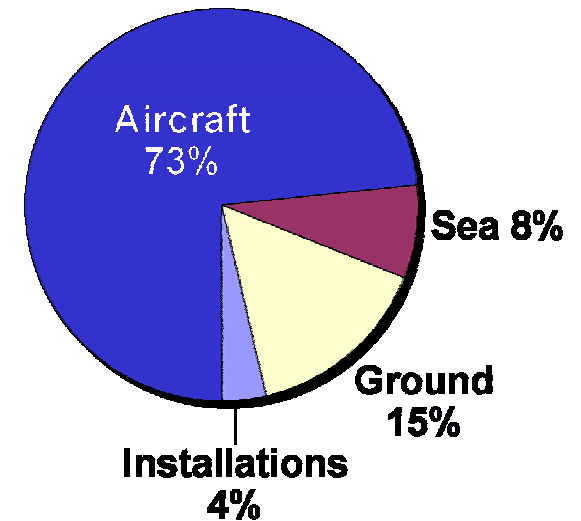
National
16,000,000 BPD



Federal Gov't (2%)
330,000 BPD



DoD (91%)
300,000 BPD



DoD Is Petroleum-Dependent ...But Cannot Drive The Market





TWV Operational Tempo and Mission Profile

- ***May 2005 IGMCM Findings from OIF:***
 - ***“The fleeting nature of insurgents demands highly responsive, highly maneuverable and highly agile ground combat power”***
 - ***All classes of TWV’s average 70-75% off road/unimproved roads***
 - ***Heavy reliance on Mobile Electric Power (MEP) throughout the AOR***
- ***Distributed Op’s further complicate TWV power & fuel***
- ***Electrical power requirements growing rapidly***

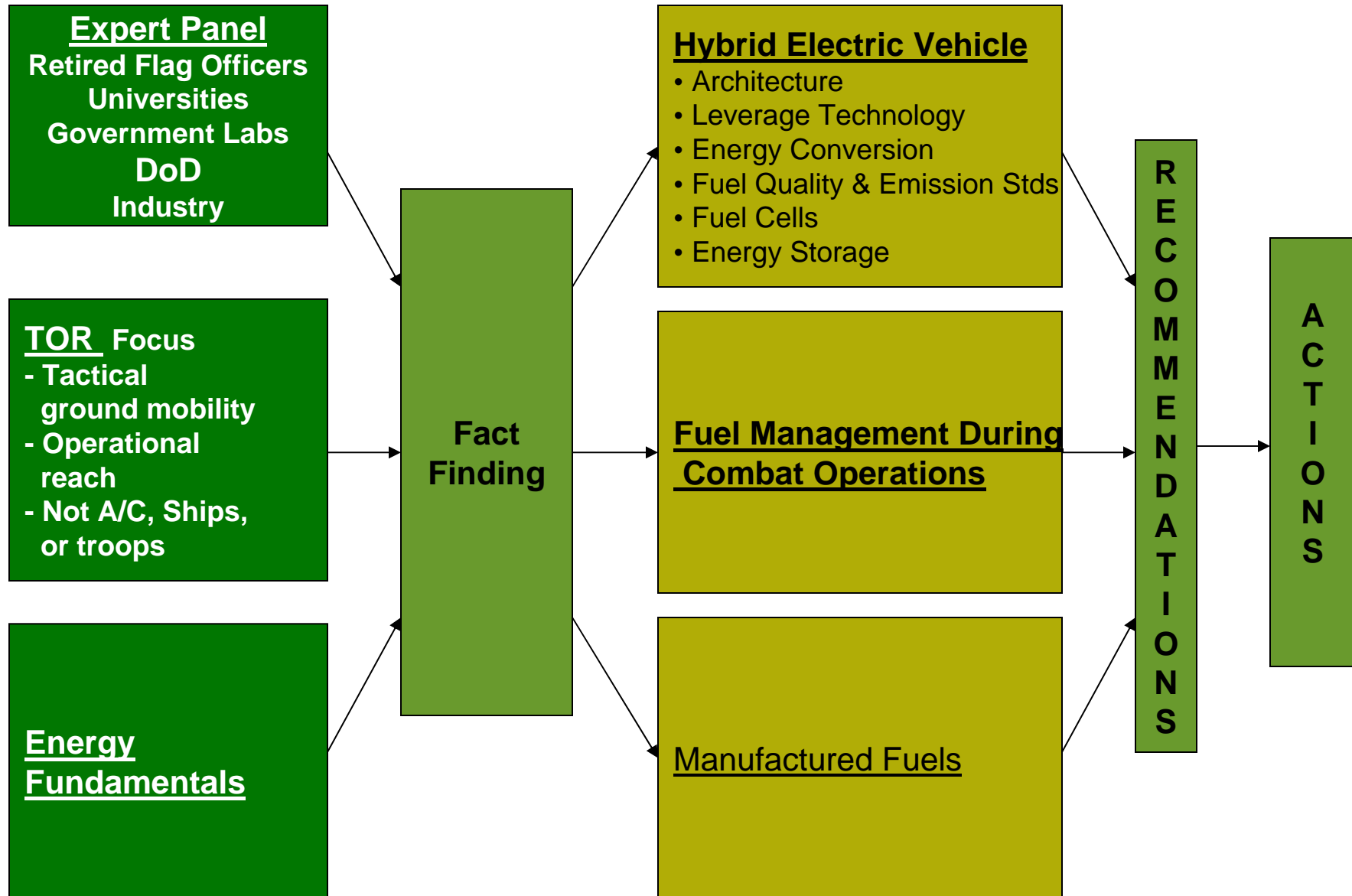
Future TWV’s...off-road fuel efficient with power generation

Future battlefield mobility requires effective utilization of fuel

- ***Nearer-term payoff (PR 07/POM 08)***
 - ***Vehicle architecture implementation***
 - ***Commander's fuel management***
- ***Longer-term payoff (2015 & beyond)***
 - ***Fuel manufacturing***

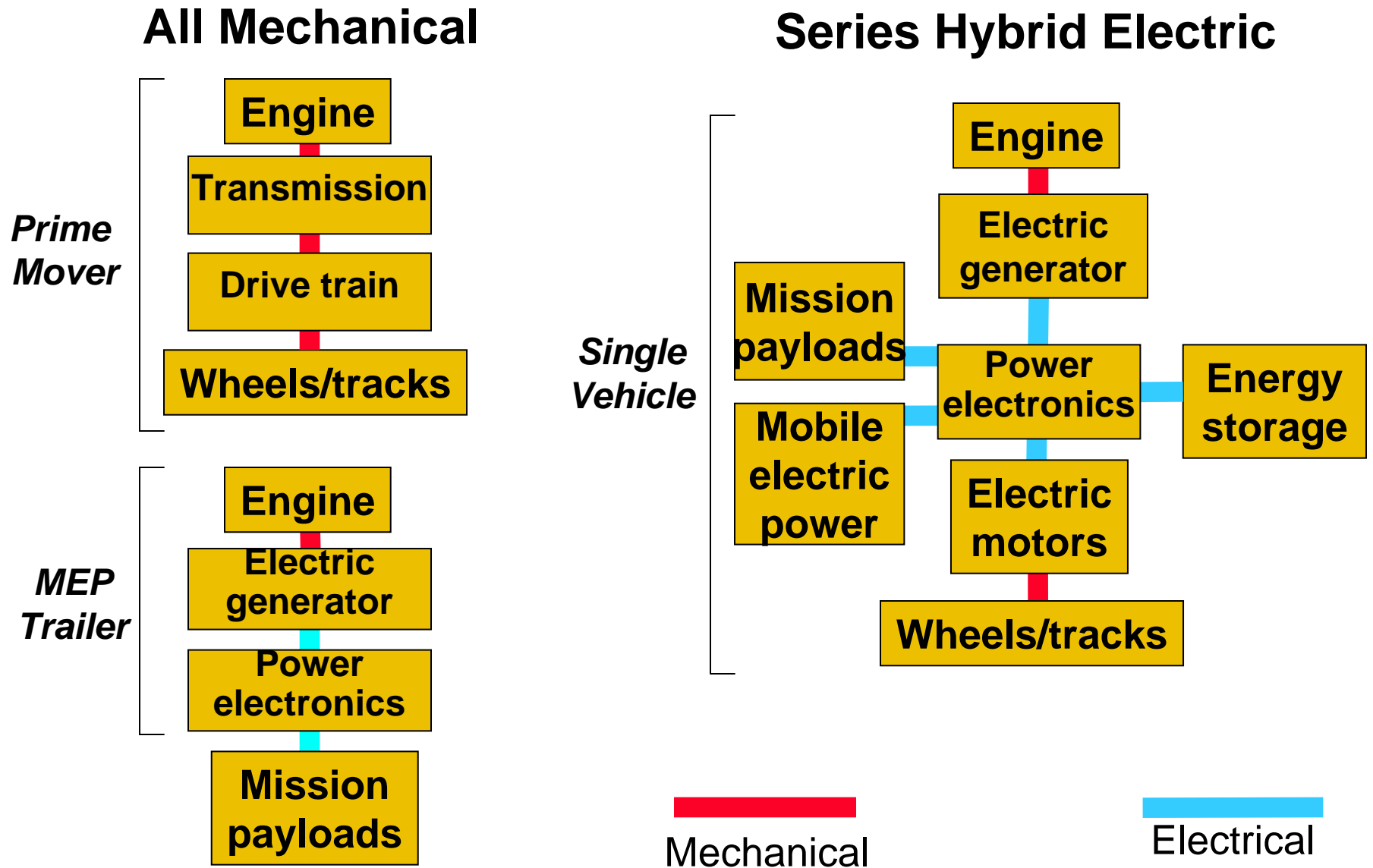


Study Flow





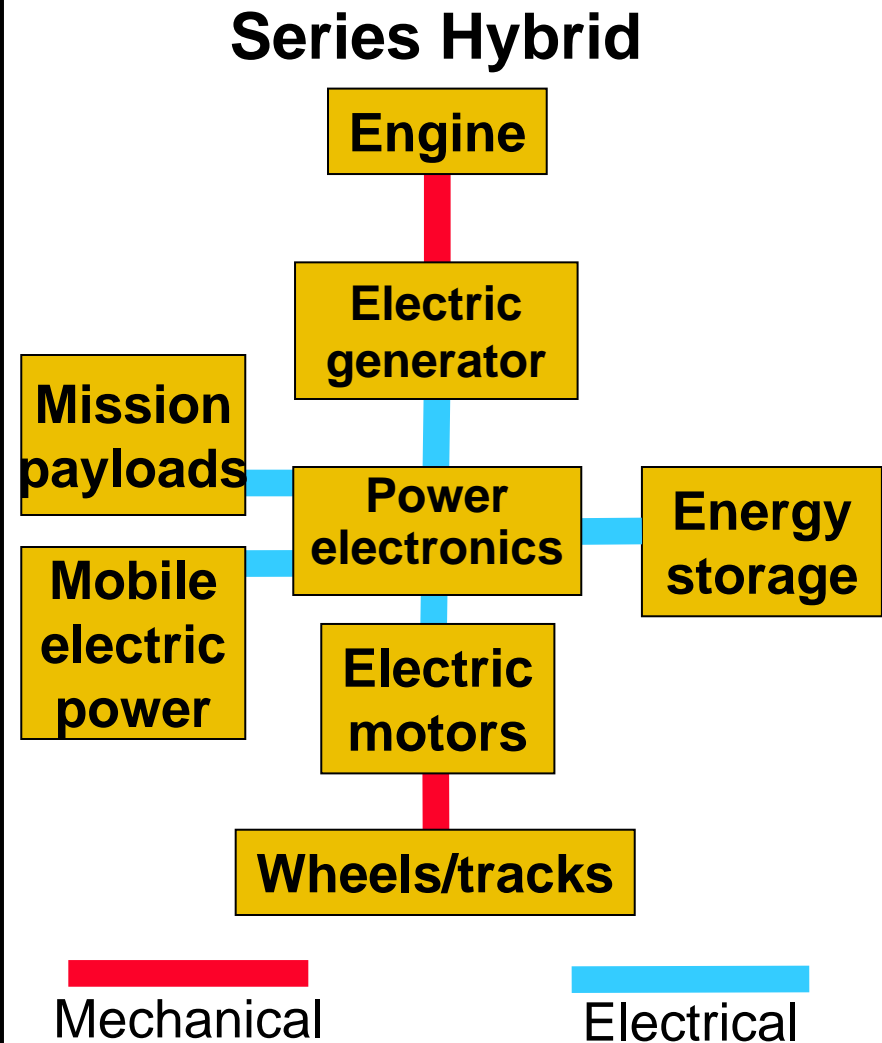
Comparison of Vehicle Architectures





Hybrid Electric Vehicle Architecture

- *Vehicle design flexibility*
- *Power distribution flexibility*
 - *traction power*
 - *mission payloads*
 - *mobile electric power*
- *Improved survivability*
- *Inherent modularity improves maintainability & upgradability (readiness)*
- *Design growth to emerging electric sources (e.g. fuel cells)*





Opportunities to Leverage Technology

Hybrid Electric Vehicles

<i>Technology/Action</i>	<i>Commercial</i>	<i>Army</i>	<i>Needed (Naval)</i>	
			<i>Fund</i>	<i>Adapt</i>
<i>Systems Engineering</i>	●	●	●	
<i>Power Electronics and Controls</i>				
– <i>Size</i>		●		●
– <i>Thermal Management</i>		●		●
<i>Energy Storage</i>				
– <i>Batteries</i>	●	●		●
– <i>Ultra-Capacitors</i>	●	●		●
– <i>Flywheels</i>		●		●
<i>Energy Conversion</i>				
– <i>Engines</i>	●			●
– <i>Fuel Cells</i>	●			●
– <i>Reformers and Desulfurization</i>		●		●
<i>Motors</i>				
– <i>Permanent Magnet</i>		●		●
– <i>Wound Rotor</i>	●		●	
<i>Series Architectures and Integration</i>				
– <i>Modeling and Simulation</i>		●		●
<i>Active Heavy-duty Suspensions</i>		●	●	
<i>Integration of Mission Systems</i>				
– <i>Weapons and Armors</i>		●	●	
– <i>Pulse Power Technology</i>		●		●
<i>Mobile Electric Power</i>		●	●	
<i>RST-V Demonstration</i>			●	



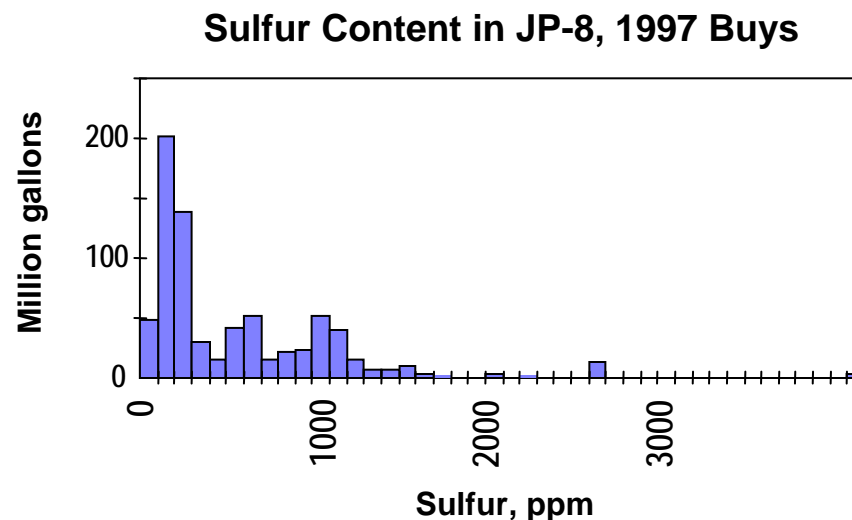
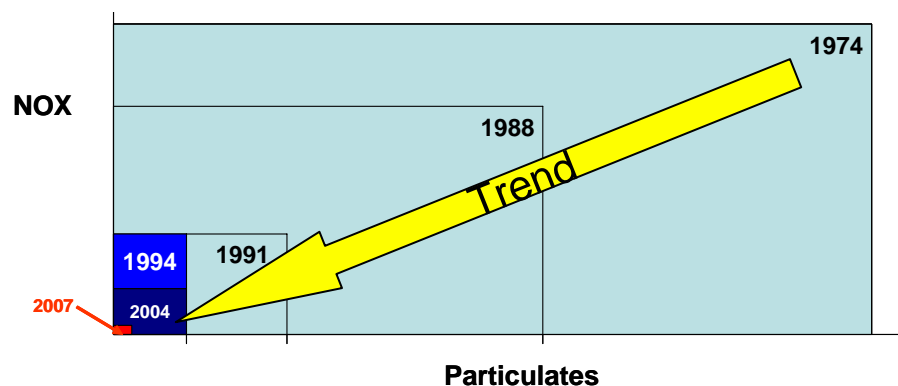
Energy Conversion Diesel Engines

- ***Most fuel efficient***
- ***Commercial engines (or derivatives) offer the most affordable choice***
- ***But... commercial sector emphasis on emissions reduction leads to problems by 2010***
 - ***Performance and RAM-D sensitivity to substandard fuels***
 - ***After-treatment emission control systems cause significant vehicle integration and signature issues***
 - ***Increased importance of emissions waiver***



Emissions and Fuel Quality Impacts

- **2010 Emission Standards -- Drastic Impact on DOD Tactical Vehicles**
 - After-treatment system as large as engine
 - Cooling system 30% larger
 - Cannot use substandard fuels without technological fix



EPA Emission Waivers Need Support



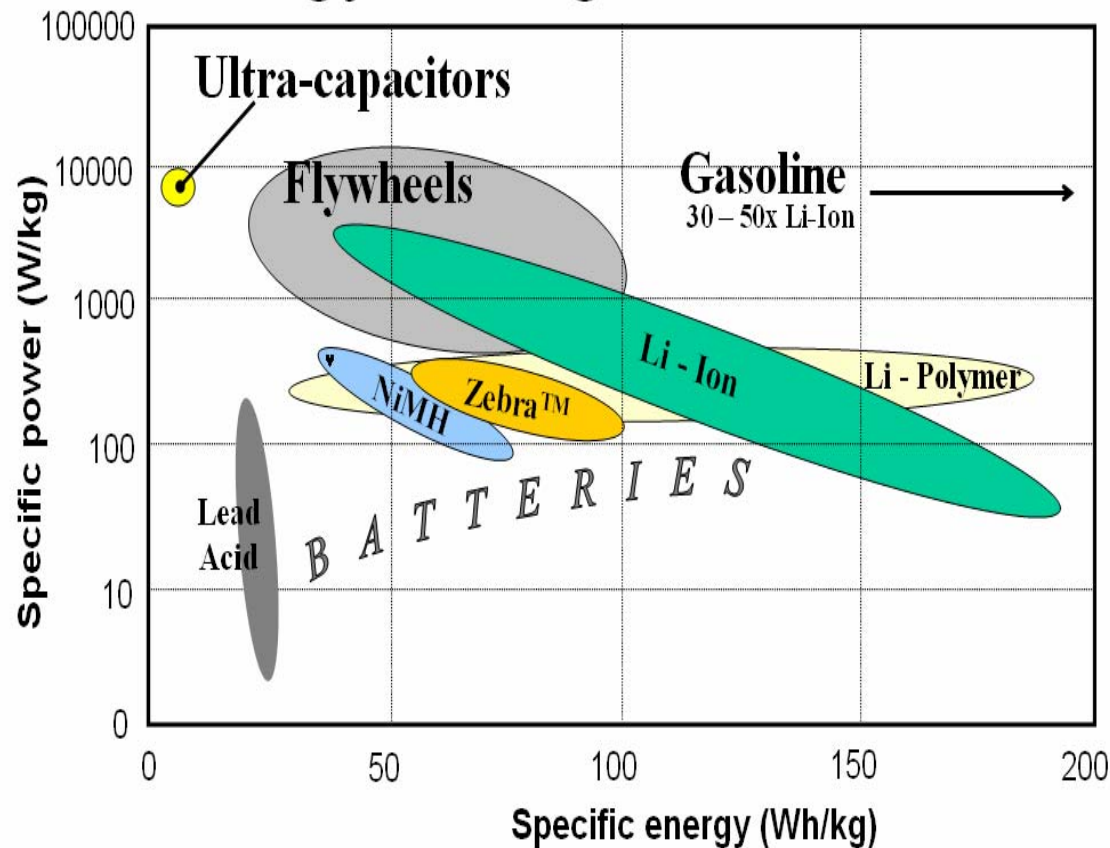
Fuel Cells

Long Term Alternative to Engines?

- ***Potential benefits***
 - *Efficiency*
 - *Pollution free, low signature*
 - *Electric power availability*
- ***Commercial sector***
 - *primary source of technology for vehicle applications*
 - *focused on hydrogen fuel*
- ***Military use: diesel fuel reformer / desulfurizer development critical***
- ***Technical challenges include:***
 - *power density*
 - *cost*
 - *low temperature operation*
 - *start-up time, throttle response*
 - *durability*

Not required for hybrid electric vehicles

Energy Storage Devices



- **Increases fuel efficiency**
 - **Reduces engine power requirement**
 - **Regenerative braking**

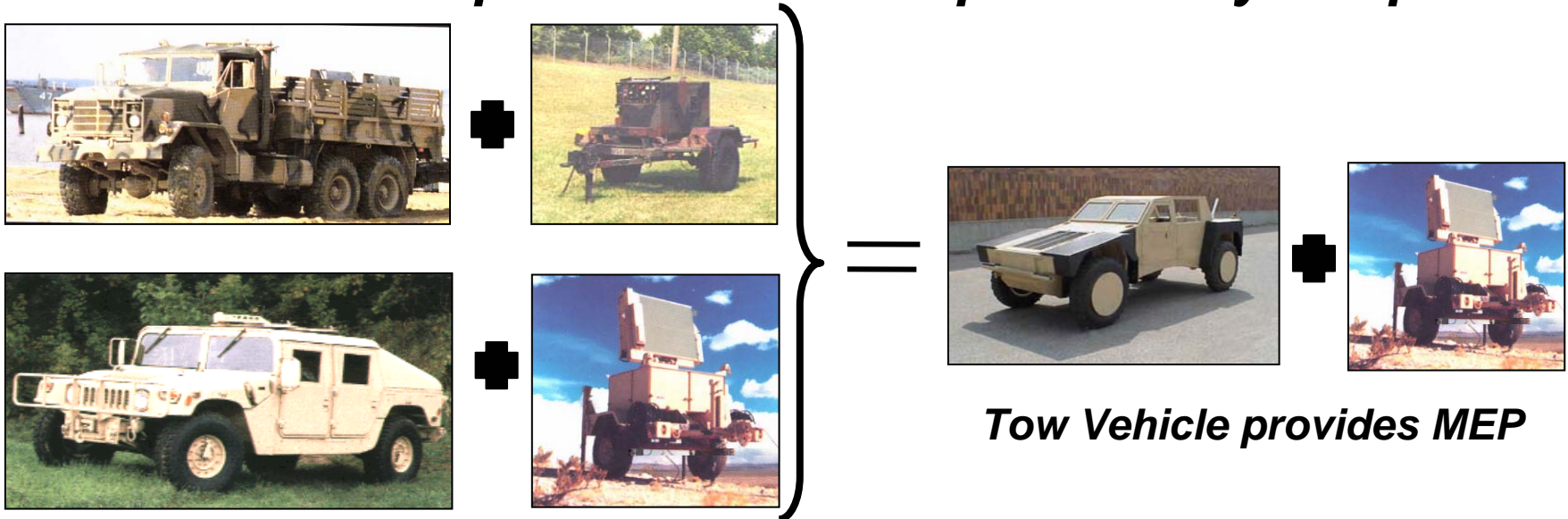
- **Challenges:**
 - **Energy density**
 - **Cost**
 - **Durability**
 - **Safety**

- **DoE and industry: Lead**

- **DoN: Stay informed**

Benefits of HEV

- ***20% improvement in fuel economy can significantly reduce existing MEF transportation shortfall***
 - ***Up to 56K gal per day (12+ trucks @ 4,500 gals/ea)***
- ***HEV electrical power reduces expeditionary footprint***



HEV Technology for TWV Replacements Can Improve Fuel Economy and Enhance Operational Capability



Conclusion: Hybrid Electric Vehicle Architecture



*GDLS/USMC/DARPA
RST-V Program:
Complete*

- 4 Prototypes in test
- 2 in OIF JAN 06

*GDLS/Army: Advanced
Hybrid Electric Drive
(AHED)*

- One demonstrator
- 19t



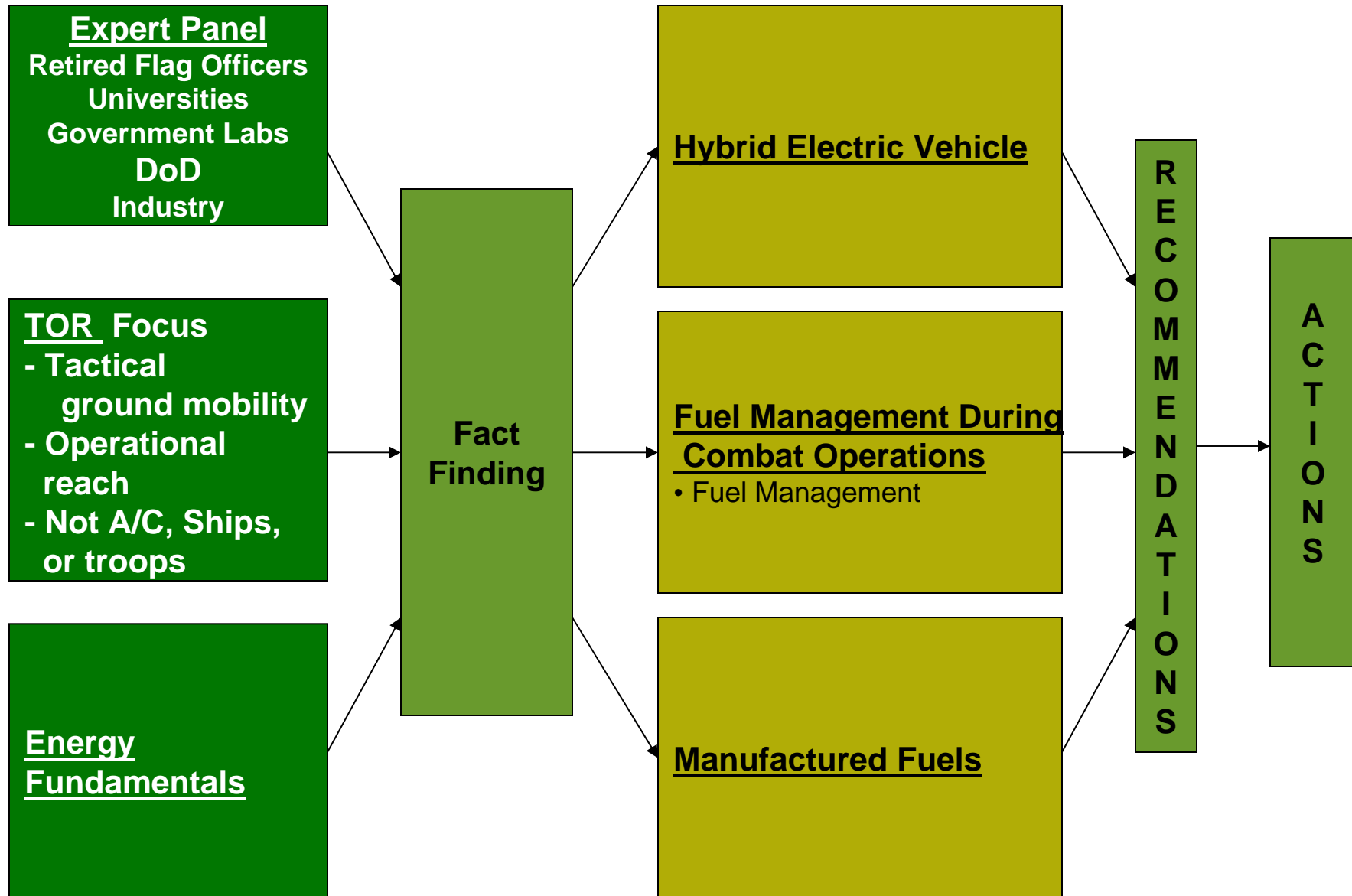
Oshkosh/Army: HEMTT A3

- 20% better fuel economy
- C130 interface
- Exportable AC power

- **Demonstrated Mission Profiles - - -**
 - Traction Control for Maneuverability / Agility
 - On/Off Road
 - Overt/Covert
 - Mobile Electric Power
- **Applicable to Unmanned Vehicles**
- **20 % - Improved Fuel Usage...but limited data**
- **Expanded Trade-offs - - Reach & Mobility versus Added Systems Capability**



Study Flow





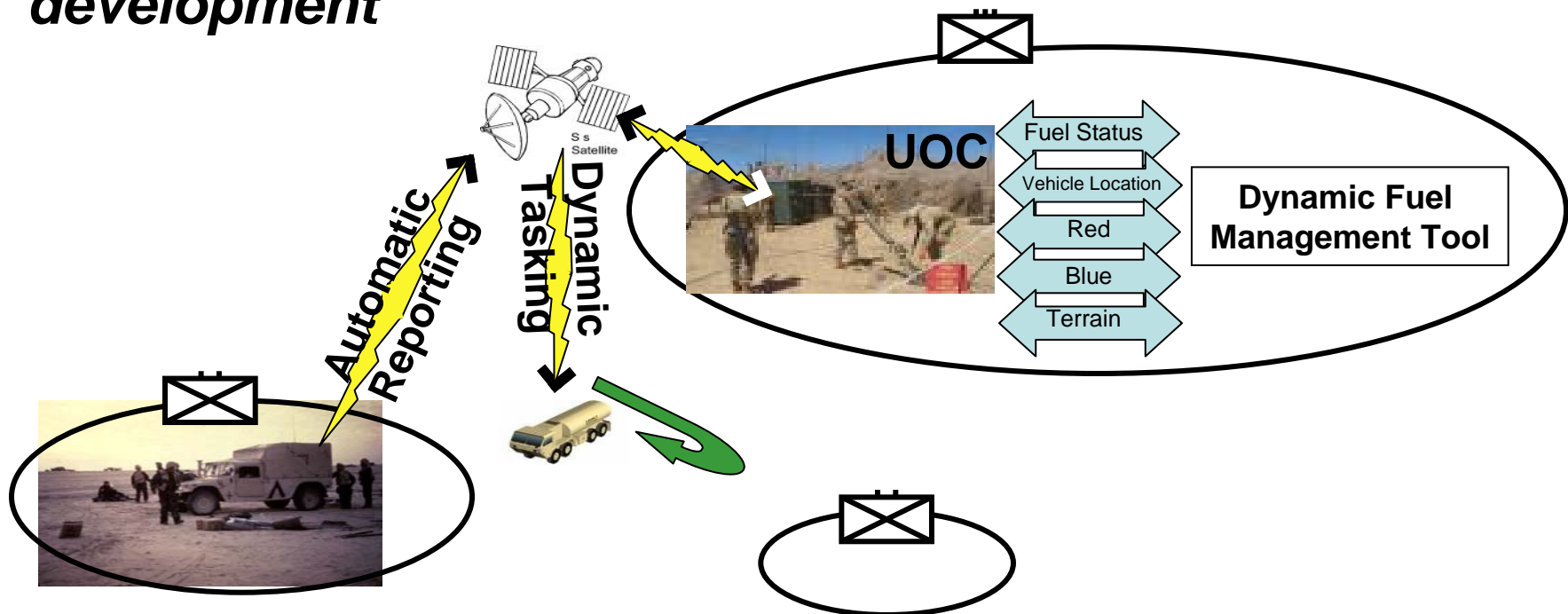
Fuel Management During Combat Operations

- ***Improved fuel management increases operational reach***
- ***Comprehensive fuel visibility/dynamic allocation:***
 - ***Conserves fuel and sustains op tempo***
 - ***Reduces the number/vulnerability of fuel trains***
- ***Marine Corps' macro fuel estimating tool needs two additional critical elements***
 - ***Automated vehicle fuel status and location reporting***
 - ***Dynamic tasking via Blue/Red/Terrain data fusion***

***Fuel is not simply a commodity or logistics issue –
it is an operational imperative***

NRAC Conclusion: Fuel Management

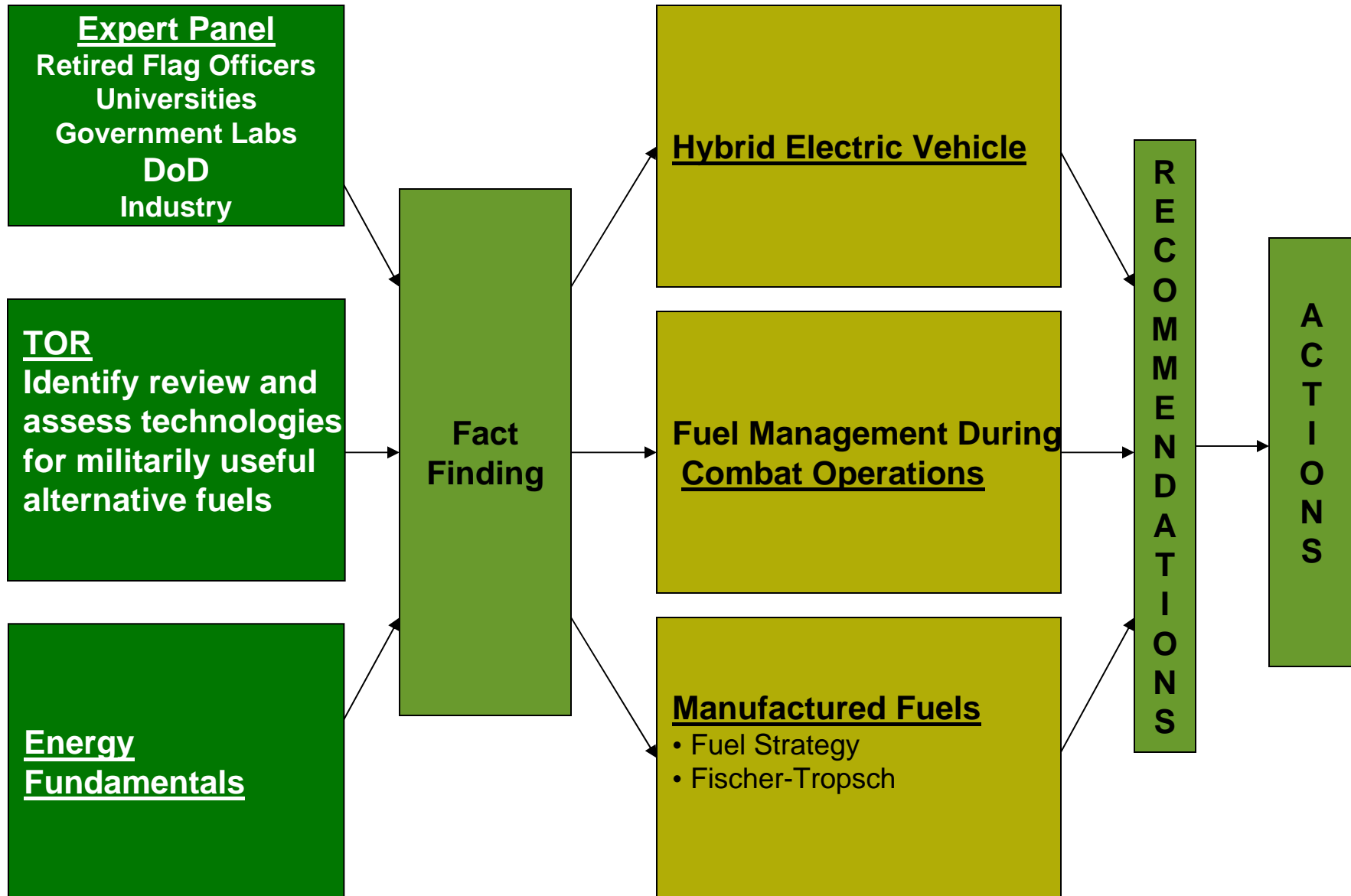
- ***New tools to improve fuel management during combat operations***
- ***Automatic vehicle location/fuel status reporting is the first step & is near term***
- ***Dynamic allocation system requires substantial development***



Future battlefield mobility requires effective utilization of fuel

- ***Nearer-term payoff (PR 07/POM 08)***
 - ***Vehicle architecture implementation***
 - ***Commander's fuel management***
- ***Longer-term payoff (2015 & beyond)***
 - ***Fuel manufacturing***

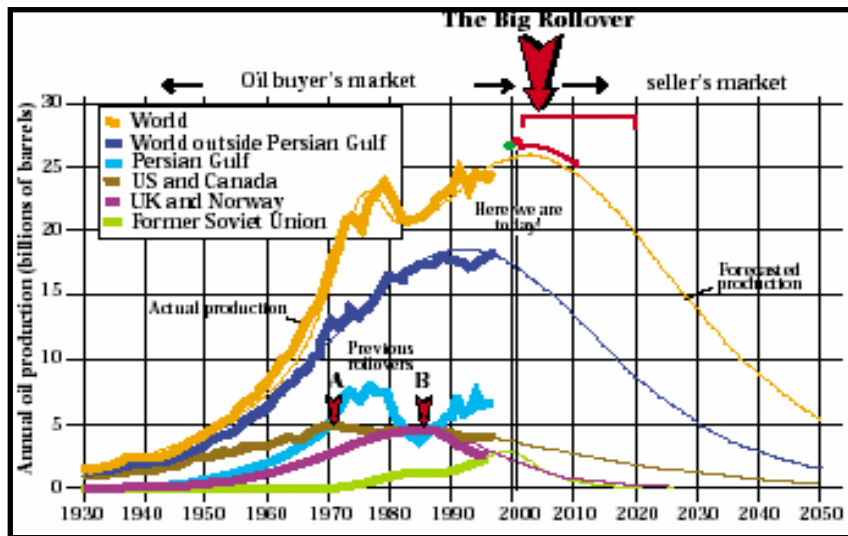
Study Flow



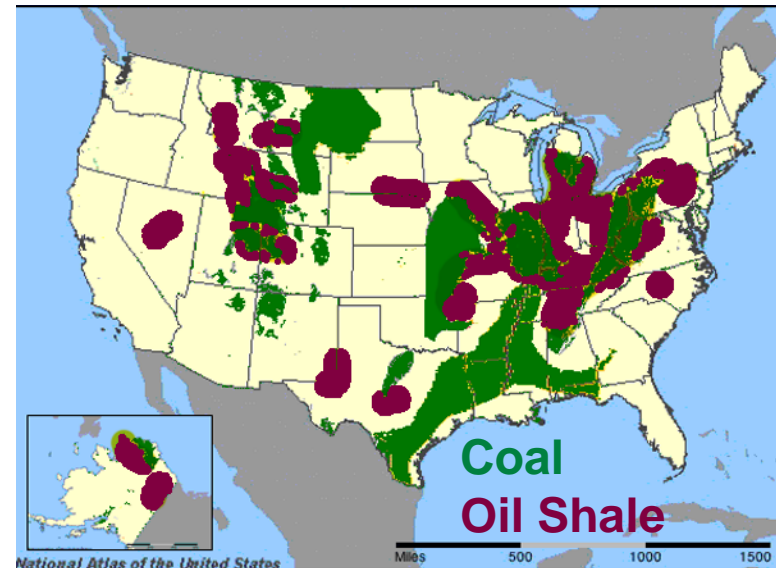


Mid-to-Far Term Fuel Strategy

- *Liquid hydrocarbon fuels have ideal properties and are needed as transportation fuels for the foreseeable future*
 - *Oil-derived fuels primarily imported and will become increasingly scarce*
 - *Existing refinery infrastructure*
 - *Predominantly coastal and vulnerable*
 - *Operating at capacity*
- *Alternative: Fuel efficiency, domestic resources, interior production*



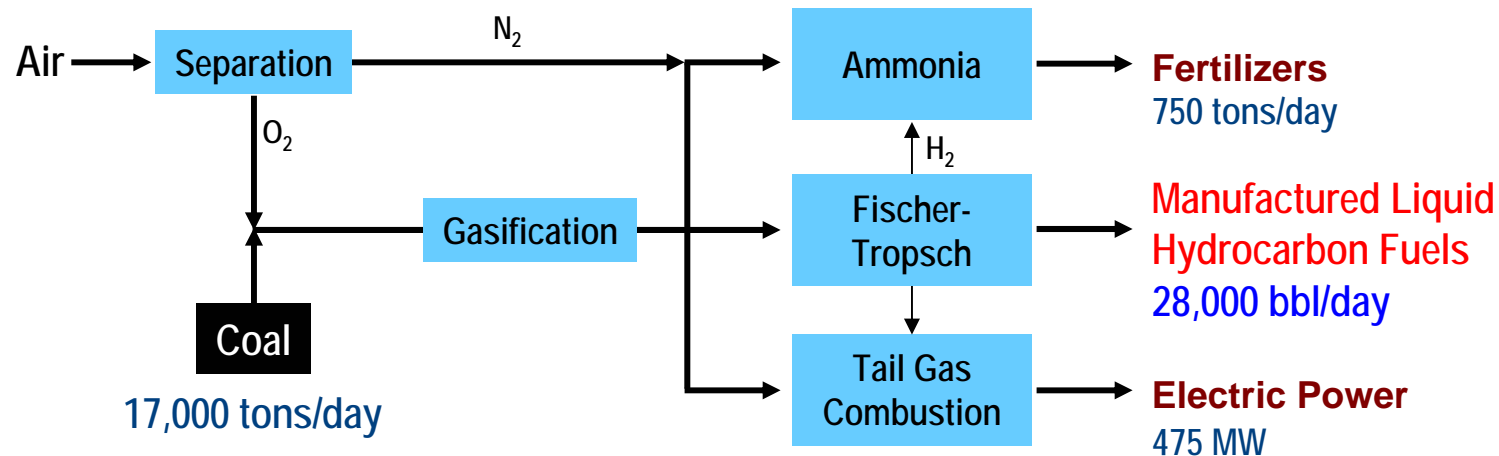
Median estimate of Hubbert's Peak
based on 11 authoritative sources: 2010





Manufacturing Fuel to Spec

- *Gasification + Fischer-Tropsch = Clean fuel from domestic sources*
- *Technology mature for natural gas, coal*
- *Significant development underway by South Africa, China, Gulf States*



Sasol Fischer-Tropsch Plant, Secunda, South Africa

- *~10 such plants would provide all DoD fuel*
- *Commercial financing of such plants viable, given DoD commitment to purchase manufactured fuels at attractive prices*

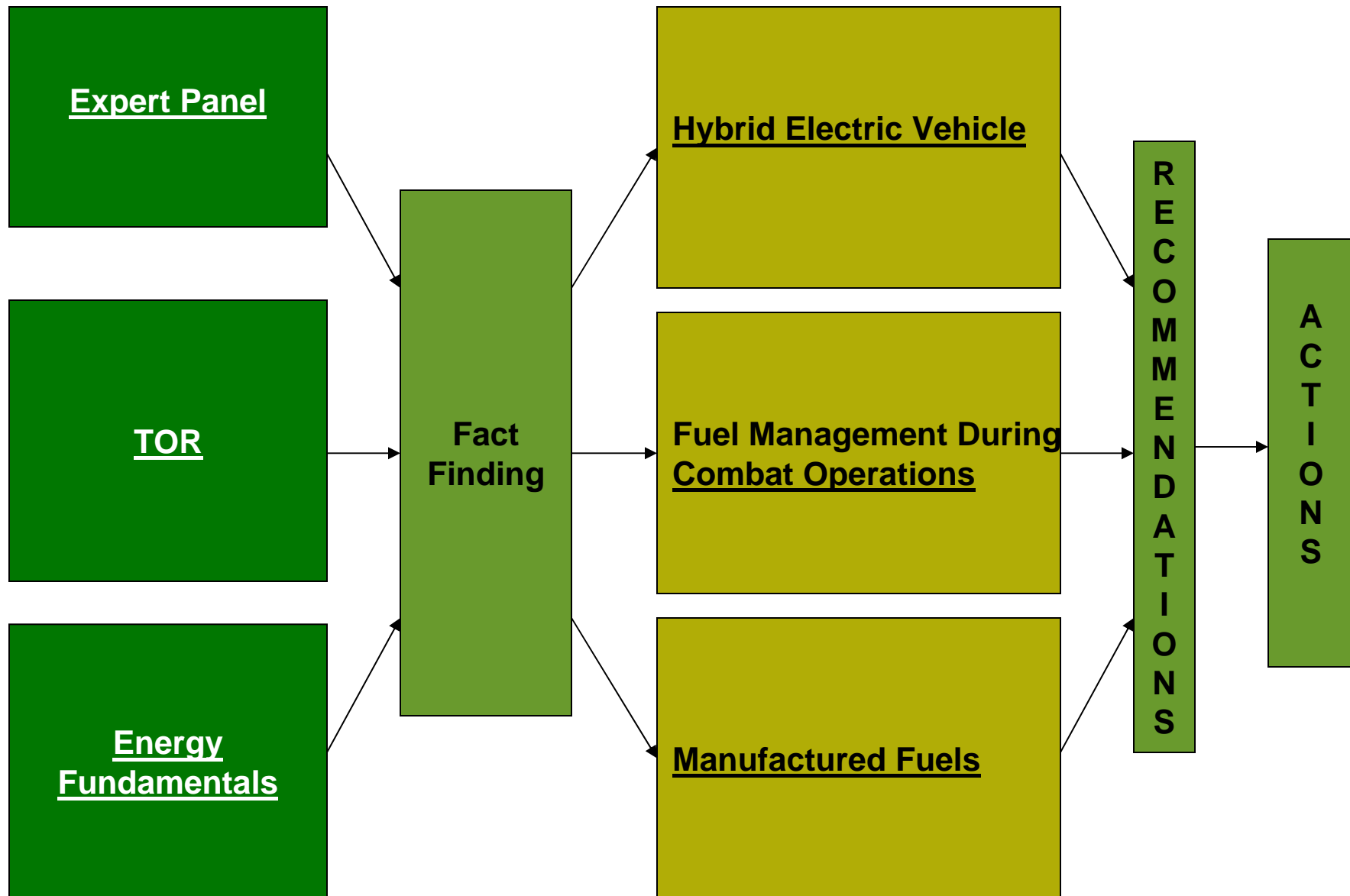


Conclusions: Manufactured Fuels

- ***Liquid hydrocarbon fuel production using domestic energy sources is feasible***
- ***Commercial financing and infrastructure development will drive this process***
- ***DoD action needed to catalyze development & ensure US military takes advantage of manufactured fuels***
- ***Need to ensure military platforms can use manufactured fuels***

***Manufacture Fuel from Domestic Sources —
Decrease Dependence on Imported Crude Oil***

Study Flow





Recommendations

Nearer-term Payoff (PR 07/POM 08)

- ***Fuel tether is still there, but...***
 - *Found a way to lengthen it (HEVs)*
 - *And untangle it (Fuel Management)*
- ***Commit to HEV technology for all future TWV***
 - *Establish an HEV development roadmap*
 - *Immediately initiate system engineering trade-offs*
 - *Invest in on-going HEV development projects*
- ***Develop prototype system to enable real-time, in-stride fuel allocation for the Operational Commander***

Longer-term Payoff (2015 & beyond)

- ***DoD catalyze manufactured liquid hydrocarbon fuels infrastructure***
- ***Characterize the compatibility of manufactured liquid hydrocarbon fuels with DoN equipment***



Actions (1)

- ***Commandant of the Marine Corps (CMC)***
 - ***Support application for emissions waiver submitted by Army***
- ***ASN (RDA)***
 - ***With Services, advocate the use of multiyear procurement authority granted SECDEF in 2005 Energy Bill to catalyze commercial financing of large-scale FT plants producing transportation fuels***
- ***CG MCCDC (Request of CNR via CMC)***
 - ***Establish new program elements (6.2 & 6.3) for HEV technologies***
 - ***Demonstrate technologies for real-time fuel asset visibility***
 - ***Develop real-time dynamic fuel allocation prototype system***
 - ***Develop conditioning technologies for substandard tactical fuels***



Actions (2)

- **CNR: Support these CMC tech investment requests**
 - **Complete RST-V Technology Program**
 - *Transition from DARPA to ONR for final maturation*
 - *Develop on-the-fly mission profile selection technology*
 - *Transition Mature Design to CG MARCORSYSCOM*
 - **Complete On-Board Vehicle Power Program**
 - *ONR Transition to CG MARCORSYSCOM*
 - **Conduct real-time fuels status tech demos**
 - **Develop Commander's real-time dynamic fuel allocation prototype system**
 - *Coordinate with DARPA to establish a joint program*
 - **Develop technologies for conditioning expeditionary substandard tactical fuels**
 - **Monitor status of FT Plant authorized by 2005 Energy Bill**
 - *Use fuel produced to conduct research on compatibility with current and future TWVs*



QUESTIONS?



Panel Membership

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